High-Frequency Maximum Observable Shaking Map of Italy from Fault Sources

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This study presents the innovative concept of maximum observable shaking (MOS) maps. Our approach makes use of the improved understanding of the Italian regional tectonic setting and uses composite seismic sources (CSS) taken from an Italian database of individual seismic sources. The CSS are merged with high-frequency scenario calculations of expected maximum shaking in a given area. The results of the MOS evaluation in terms of peak ground acceleration and peak ground velocity have been converted into Mercalli-Cancani-Sieberg intensities and are compared with historical felt intensities from the Italian DBMI04 macroseismic database.

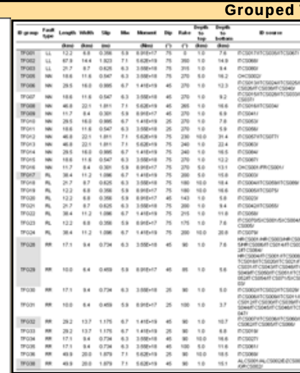
The procedure of HF MOS map computation

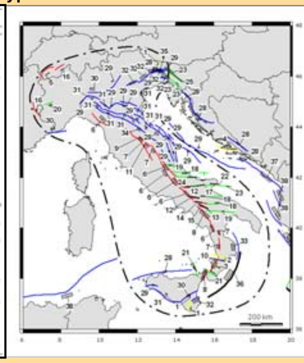
1. **Maximum Credible Earthquake** (MCE): this is defined for each CSS, and a TF is associated with it. Each CSS includes a number of TFs;
2. **Credible rupture parameters**: the MCE is modeled according to a rectangular fault plane (i.e. the TF). The rupture model of the TF is defined by a random or Gaussian slip distribution and some other parameters;
3. **HF wavefield**: computed at all sites within the simulation domain for any given MCE and TF;
4. **Ground-shaking computation** in terms of PGA, PGV, spectrum intensity SI-HI and displacement response spectra SD(10sec) at the site;
5. **MOS map**: as the TF floats along and across the CSS, we allow the shake map to 'float' as well, and we pick the maximum shaking at each grid point of the entire simulation domain.

Composite Seismic Sources of Italy

The map of the Composite Seismic Source (CSS) from the DISS, version 3.1.0 database (DISS Working Group, 2009), classified according to faulting mechanism: **red**, **normal (NN)**; **blue**, **reverse (RR)**; **green**, **right-lateral (RL) strike slip**; **yellow**, **left-lateral (LL) strike slip.**

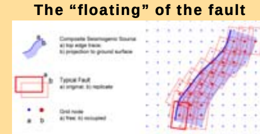
Grouped Typical Faults





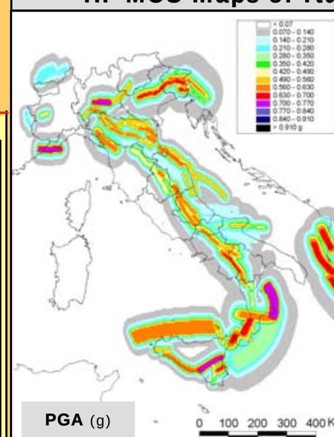
To keep the number of simulations to a minimum, we grouped all of the TFs according to their faulting mechanism, magnitude, depth of the top of the fault, and dip angle.

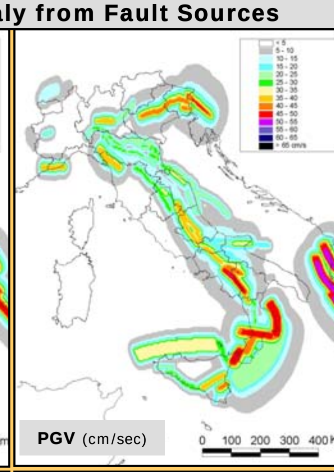
The "floating" of the fault

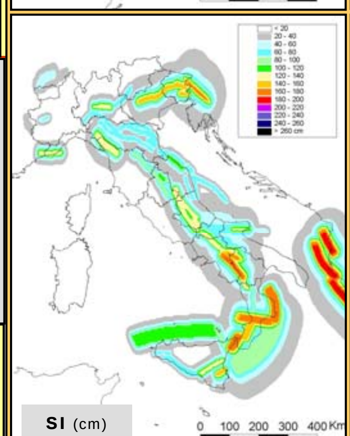


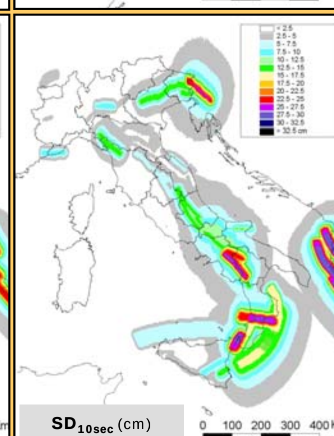
The Typical Fault floats along the CSS, the high-frequency ground motion is computed at each point surrounding the given fault, and the maximum from the observable shaking is plotted on the MOS map.

HF MOS maps of Italy from Fault Sources







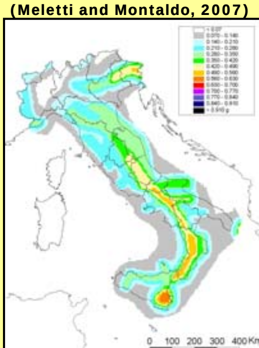


A finite-fault stochastic simulation (Gaussian slip) generates the HF MOS maps of Italy in terms of the peak ground acceleration (PGA), peak ground velocity (PGV), spectrum intensity-Housner intensity (SI-HI), and displacement response spectra (SD_{10sec})

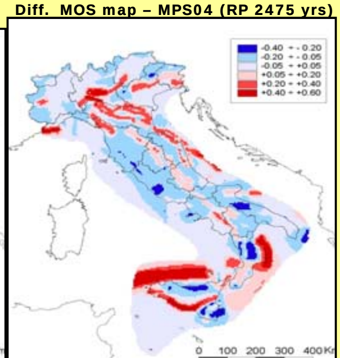
1° Comparison

The results of the **MOS** in terms of the PGA (g) were compared with the probabilistic hazard map **MPS04** (R.P. 2475 years) under the assumption that the maximum observable shaking was related to 2,475 years return period earthquake

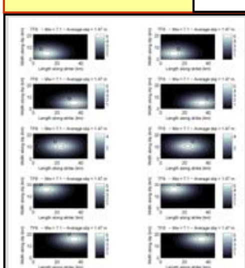
MPS04 Map (R.P. 2,475 yrs) (Meletti and Montaldo, 2007)

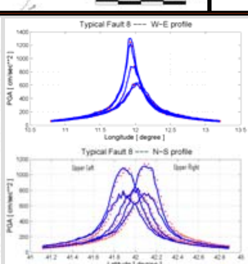


Diff. MOS map – MPS04 (RP 2475 yrs)



Uncertainty and variability





The PGA mean of the stochastic simulations (EXSIM) are shown for TFG8 (M_w 7.1 and dip 45°)

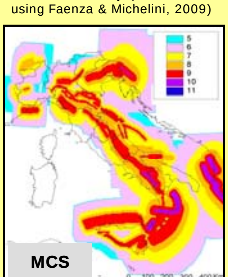
The results were obtained with the five patches of Gaussian distribution with the nucleation points on the left and the right

The effect of the floating process along the CSS did not change using the patches in the middle and on the bottom of the fault.

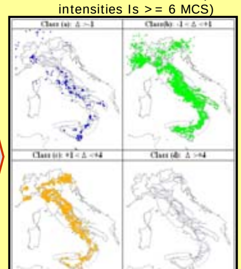
2° Comparison

The results of the **MOS** in terms of intensity (**INT_MOS**) are compared with the maximum felt intensities **DBMI04** occurred on the Italian territory. The intensities are expressed in MCS (Mercalli Cancani Sieberg) using also the half degree intensity.

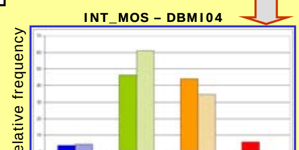
INT_MOS Map (from **PGV** using Faenza & Michelini, 2009)



INT_MOS – DBMI04 (for intensities Is >= 6 MCS)

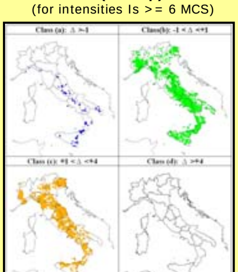


INT_MOS – DBMI04

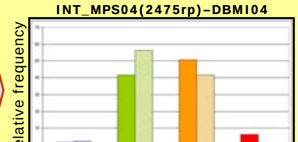


We compare the **MPS04 map (RP 2,475 yr)** with the historical felt intensities using the Faenza and Michelini (2009) to derive intensities from ground acceleration, we observe similar patterns on the results obtained comparing (see above) **INT_MOS–DBMI04**

INT_MPS04(2475rp)–DBMI04 (for intensities Is >= 6 MCS)

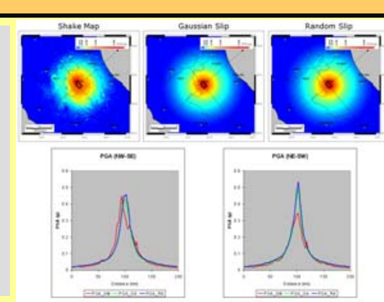


INT_MPS04(2475rp)–DBMI04



3° Comparison

We have run, using the tools of MOS procedure, a shaking computation for both **Gaussian** and **random** slip distributions of the fault that presumably caused the **L'Aquila earthquake** (Mw 6.3, 6 April, 2009) (Michelini, 2010 pers. comm.) to compare the results from **our procedure** to those computed directly by **ShakeMap.** On the right, the comparison for the PGA parameter



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